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None

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UK CL (Edition J) F3C CGB CGD CGX , G1A AEE , H4D
INT CL^{4} F41G , G01B , G01S
None

(54) **System for the spacial referencing of a direction associated with a moving body with respect to a structure.**

(57) The system enables an accurate spatial referencing of a direction associated with a moving body, eg. a helmet aiming sight. It uses two sensors (3A, 3B) of solid matrix (7A, 7B) type made of charge-coupled devices. These sensors are carried by the structure eg. an aircraft cockpit, and are advantageously formed by miniature cameras. The helmet (2) carries light-emitting bands placed parallel to the direction (DR) to be referenced, these bands being made from either a fluorescent or back-reflecting material. In the latter case, a light-emitting source (15) eg. infrared, is used to illuminate them. The referencing is based on the fact that the analysis of the image of the bands on the sensors enables the definition of at least two secant planes (PA, PB, Fig.3, not shown) each passing through any of the image bands and the associated corresponding optical centre and that their straight line of intersection is a line parallel to the direction to be referenced. A less accurate system employing but one sensor (Fig. 4, not shown) is also described.

FIG_2

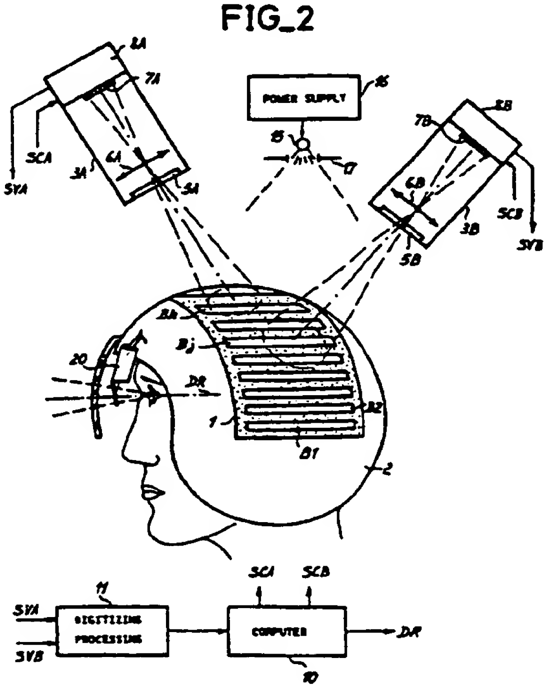

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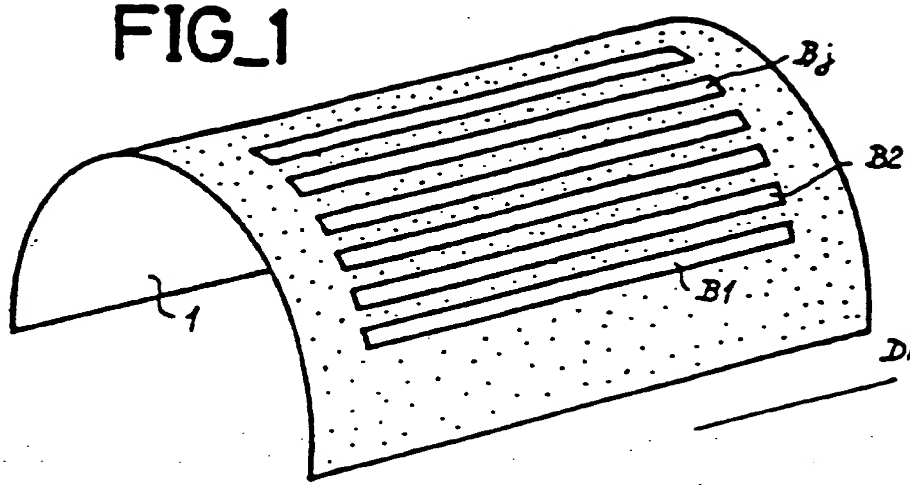
FIG_1


Bj
B2
B1
1
DR

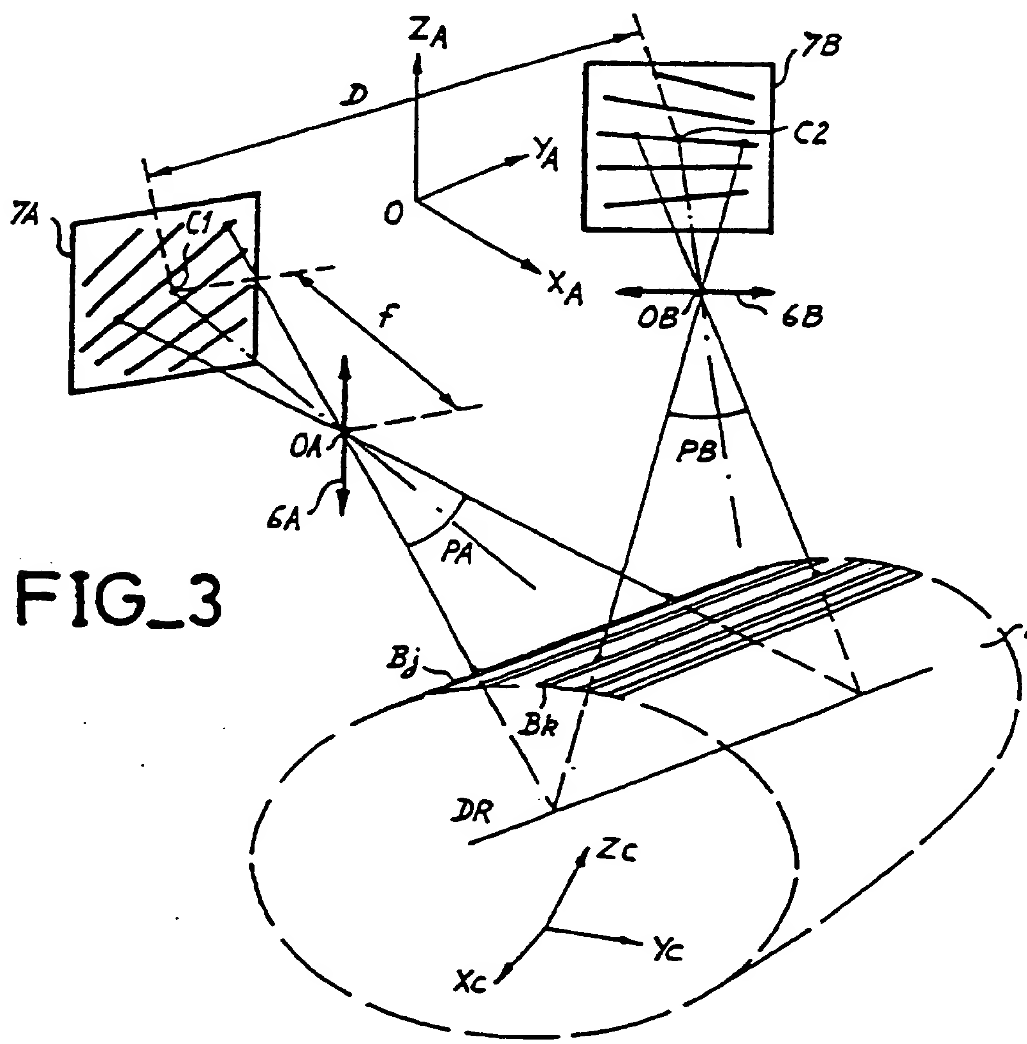
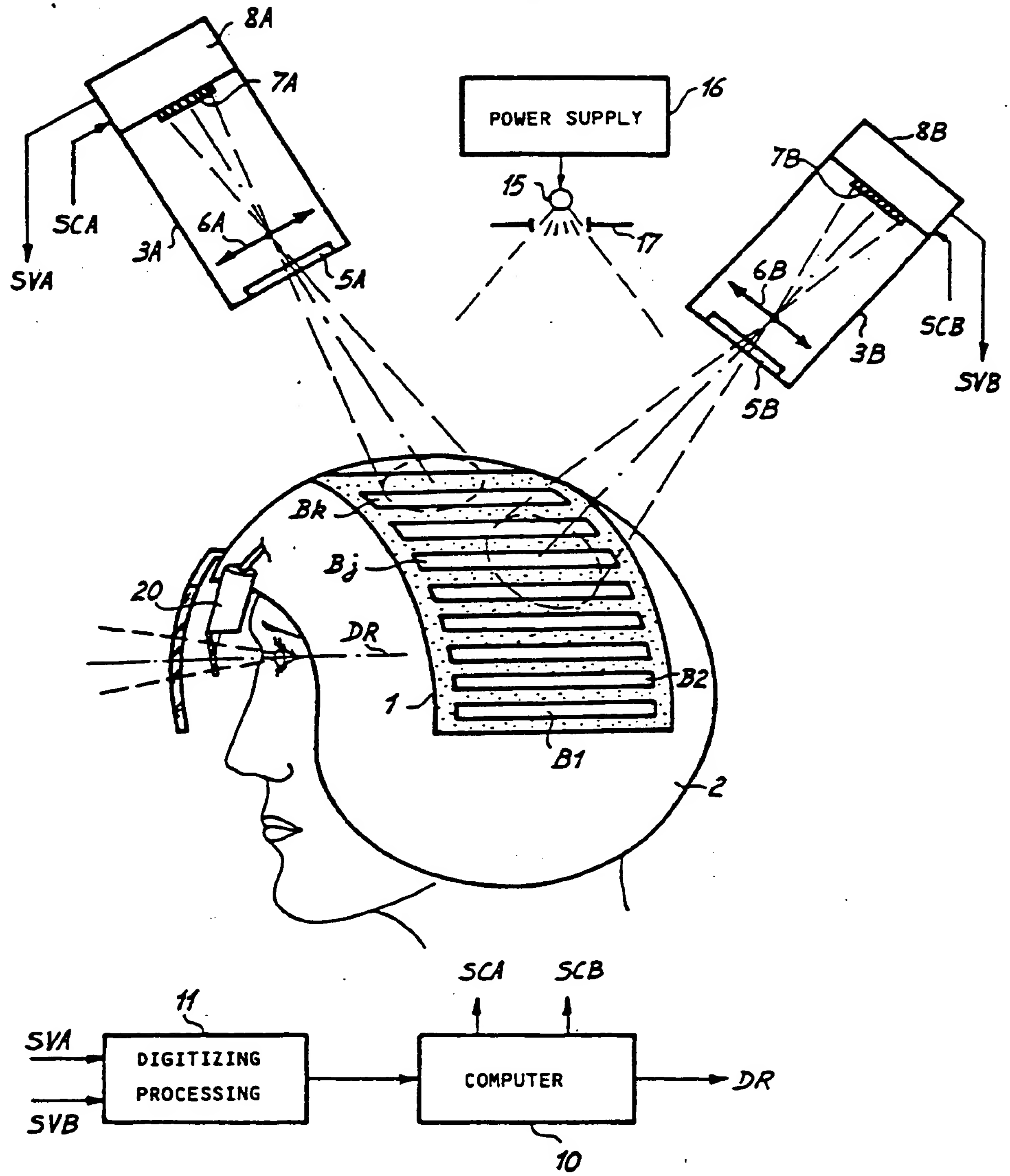

ZA
D
7B
C2
YA
7A
C1
O
XA
f
OB
6B
OA
6A
PB
PA
2
Bj
Bk
DR
Zc
Yc
Xc

FIG_3

FIG_2



8A
7A
SCA
SVA
6A
3A
5A
POWER SUPPLY
16
15
17
8B
7B
6B
SCB
3B
SVB
5B
Bk
Bj
20
DR
B2
1
B1
2
SCA
SCB
11
SVA
SVB
DIGITIZING
PROCESSING
COMPUTER
DR
10

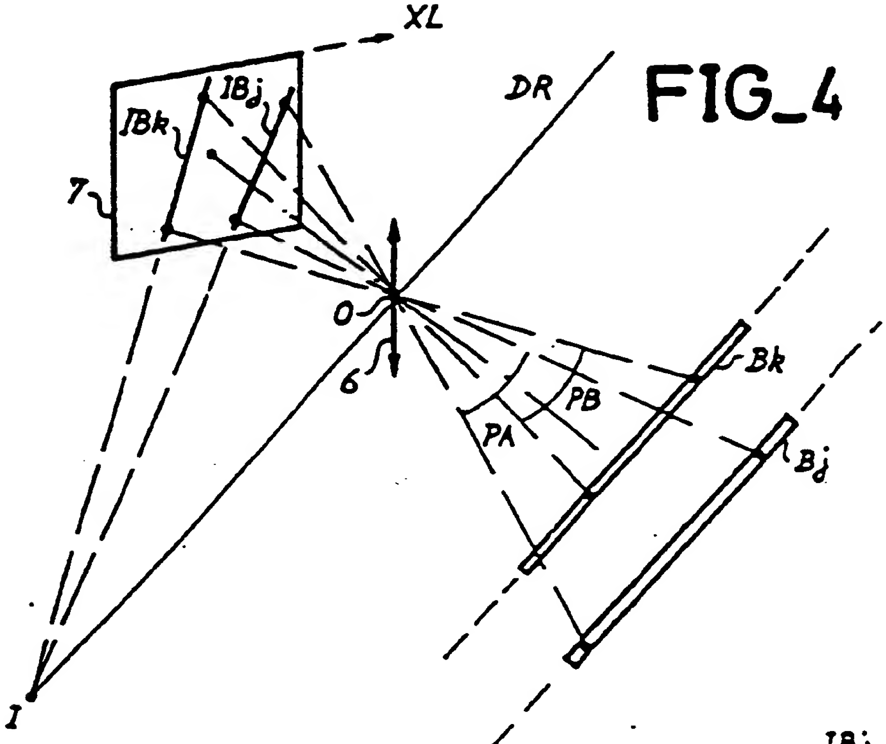


FIG_4

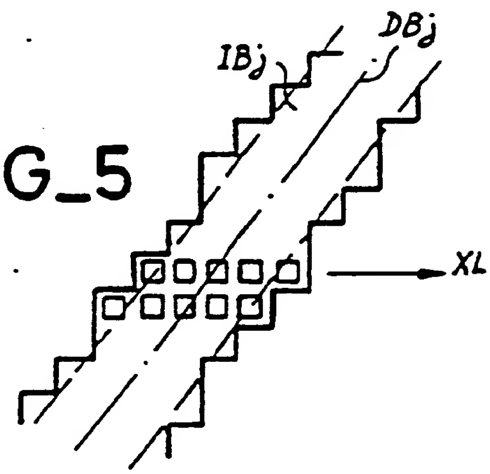


FIG_5

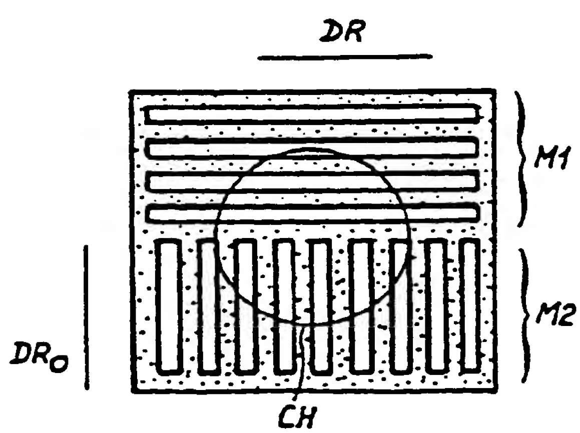


FIG_6

2300988

A SYSTEM FOR THE SPATIAL REFERENCING OF A DIRECTION ASSOCIATED WITH A MOVING BODY WITH RESPECT TO A STRUCTURE, USABLE IN PARTICULAR FOR A HELMET AIMING SIGHT

The present invention relates to a system for the spatial referencing of a direction associated with a moving body with respect to a structure. Such a system enables the determination of the relative orientation of the moving body with respect to a surrounding structure which is the case in particular for the application more particularly envisaged in the aeronautical field where the moving body is constituted by the pilot's helmet fitted with an aiming sight and the structure is constituted by the cockpit.

Systems of this type are produced in various ways which are divided into two major categories, optical solutions and magnetic solutions. The object of the invention relates to an optical type solution. Such a solution can be constituted with a group of light emitting diodes mounted on the helmet, one or more sensors mounted on the cockpit and an appended computer which processes the detected signals in order to measure the reference direction associated with the helmet. A successive sequential powering of the diodes is produced from the computer. The sensors are mounted in the aircraft and the computer can, at any moment, give the spatial position of a defined direction associated with the helmet, this reference direction preferably being chosen corresponding with the aiming direction of the pilot. A solution of this type is described in particular in the French patent 2,399,033. The sensor is constituted by means of a detector device preferably formed from three sub-assemblies each including a linear array of photo-sensitive elements coupled to a cylindrical diopter of perpendicular direction in order to determine three planes passing through the emitting light source and to produce, by an associated computa-

tion, the corresponding spatial location of that source, and then that of a triangle formed by a set of three sources and, consecutively, to determine the direction to be referenced.

A big disadvantage of these devices is in the fact that the optical efficiency is very poor, given that the slit associated with the cylindrical diopter is about 150 microns wide and that the light energy transmitted by the light emitting source through this optical system and this slit and arriving at an element or at several elements of the detector array remains very limited.

According to another known solution described in French patent 2,433,760, the helmet returns a radiation by back-reflection and this radiation arrives at an X,Y matrix of elements electrically controlled by a control circuit and by a computing circuit in order to make the elements pass from the opaque state to the transparent state according to a predetermined selection program. A single photo-detector downstream of the matrix powers the computing circuit which provides the angular deviation measurement of the back-reflector device. Several back-reflectors are provided to perform the function of diodes and thus to determine a direction associated with the helmet. According to this solution the electrically controlled matrix can be produced from liquid crystals of nematic type or by a PLZT ceramics-based optoelectric shutter device. Such a solution proves to be complex, its installation delicate and its use requires a certain period of time in order to scan the matrix element by element.

The object of the invention is to produce a system for the spatial referencing of direction which enables the disadvantages of the abovementioned solutions to be overcome using solid circuit matrix detector structures.

According to the invention it is proposed to produce a system for the spatial referencing of a direction associated with a moving body with respect to a structure, using means of emission carried by the body and

means of opto-electric detection carried by the structure in order to define, by analysis of the detected signal and a computation, secant planes and by the straight lines of intersection of these planes, the direction to be referenced, wherein ____________ the detector means are constituted by at least one solid matrix sensor made from a charge transfer device associated with focusing optics, the means of emission being formed by an array of parallel emitting bands separated by opaque intervals and arranged on the body parallel to the direction to be referenced, in such a way that the image of the bands on the detector means is analyzed in order to define at least two secant planes, each with any image band whatsoever and the centre of the corresponding associated optics, and their straight line of intersection which is parallel to the direction to be referenced.

The features and advantages of the invention will appear in the following description given by way of example with reference to the appended figures which show:

- In figure 1, a diagram of the means of emission produced in the form of fluorescent or back-reflecting bands;
- In figure 2, a first embodiment of a referencing system in which the invention is embodied, using two viewing cameras;
- In figure 3, a diagram illustrating the process implemented in the system according to figure 2;
- In figure 4, a diagram illustrating the process implemented in a system in which the invention is embodied but using only a single viewing camera;
- In figure 5, a partial diagram of the image of a band on a matrix sensor showing the sensitivity presented by the system for the measurement;
- In figure 6, a diagram of a variant embodiment of the pattern of bands for measuring the roll of the moving object about the direction to be referenced.

Figure 1 shows a geometric pattern constituted of bands B1, B2, ... Bj ... etc. ... emitting light,

parallel to a reference direction DR to be referenced. These bands can be reflecting bands or made from a fluorescent material or a back-reflecting material. It is known that these elements are easily produced in the form of an adhesive band or by painting. The separating intervals between the emitting bands are opaque; they can be produced by the support part 1 painted with a matt black paint for example. The support 1 of the bands can be a plane or a curved surface as shown by way of example by a lateral section of a cylinder. The light emitting source in the case of fluorescent bands is constituted by the ambient lighting. In the case of back-reflecting bands, a light source is used whose field of illumination covers the area of the pattern to be illuminated; this source is situated in the vicinity of the optoelectric detector devices.

Figure 2 shows an example of embodiment of the referencing system applied to a helmet aiming sight, it being understood that the referencing of directions is not limited to this case. In this example, the means of emission detailed in figure 1 are carried by the pilot's helmet 2 which constitutes a moving body with respect to the surrounding structure which is the cockpit of the aircraft. The surrounding structure is fitted with two optoelectric sensors 3A, 3B which are of the solid matrix detector type produced with charge transfer devices known as CTD devices. In this first version, two sensors can consist of two standard miniature cameras 3A and 3B, each of the cameras including a means of optical filtering 5, for example an interferential filter, an optical objective 6 and the detector matrix 7 which is followed by scanning and reading circuits 8. These circuits can be remote controlled from an associated computer 10 which produces the corresponding control signals SC. The detected video signals SV (SVA and SVB respectively) are processed in circuits 11 and transmitted to the computer 10 in digital form in order to carry out the computations of the direction DR. The cameras

are directed towards the helmet such that the spatial volume provided by the displacement of the pilot's head remains within the field of the camera so that this camera always sees a small section of the geometric pattern constituted by the emitting bands. As the volume of movement of the pilot's head is limited as is the optical field covered by the camera, it is possible to derive from them the dimensions to be produced for the pattern also taking account of the rather small distance separating this pattern from the detection cameras. In the case of back-reflecting bands, the device also includes a source 15, for example a light emitting diode which emits in the infra-red spectrum. This source is powered by a circuit 16 and associated with a diaphragm 17 in order to illuminate a field enclosing the volume of movement of the helmet.

Figure 3 shows the functioning of this arrangement. The matrices 7A and 7B, as well as the associated objectives 6A and 6B, are integral with the structure which is referenced by the axes XA, YA, ZA. The bands B1, B2, etc. ... are carried by the body 2 referenced by the axes XC, YC, ZC, of the moving body with respect to the structure. The image of the bands on the sensors forms an array of straight and generally converging lines (exceptionally, these can be parallel if the optical axis is perpendicular to the direction DR). If the image of the bands on each of the sensors is considered, this band image determines, with the center OA or OB of the associated optics, a plane which must pass through the corresponding emitting band B_j or B_k. Now, as these bands are parallel, the intersection of these two planes PA and PB must be a straight line parallel to the sought reference direction DR. The position of the sensors with respect to the reference axes of the structure is known as is the distance D between the centers C1 and C2 of these sensors. The focal lengths f between the sensor and the center OA, OB of the associated objective is also known. Consequently, the computer can

easily determine each of the planes PA and PB with reference to the XA YA ZA reference axes and from them can derive the direction of the straight line of intersection DR, this straight line being able to correspond, as shown in figure 2, with the normal sight aiming direction of the pilot.

Figure 4 is the functional diagram of a simplified but less accurate design in which no more than a single CTD camera is used in order to determine the direction DR to be referenced. On the matrix 7, the image of the bands forms an array of straight lines converging at a point I. Any two of the emitting bands is considered, B_k and B_j, each of which forms, with its image, a plane passing through the center O of the associated objective. These two planes PA and PB must pass through the point of intersection I which represents the image of the points of intersection of the bands B_k and B_j which is a point projected to infinity. From this it is derived that the straight line of intersection IO of these planes corresponds with the reference direction DR to be referenced. The computer 10, as before, determines the planes PA and PB, as well as the point of intersection I of the band images (this point is in the plane of the sensor) and from this it easily derives the straight line of intersection IO representing the direction DR.

Figure 5 illustrates the accuracy provided by the described solutions by means of a detailed diagram. This accuracy is great considering that one band image IB_j can cover several pixels along the direction XL of line scanning which enables an accurate determination of the central direction DB_j of the band image IB_j by averaging the detected values.

Thus the proposed system enables the determination of a direction in space with reference to a given set of reference axes and is particularly applied to the measurement of the orientation of the line of sight of a pilot with respect to the aircraft axes. It uses one or

two standard cameras, an easy to produce geometric pattern and has numerous advantages, in particular a negligible weight and volume. In the helmet aiming sight appliication, a graticule collimated by a collimating device 20 (figure 2) symbolizes the aiming direction DR which must be measured. The geometric pattern 1 is placed on the helmet, either directly if the surface is suitable in order to obtain a configuration of parallel bands, or using a support of the type shown in figure 1 if the longitudinal flatness in the direction of the bands is not sufficiently complied with by the surface of the helmet.

The geometric pattern is particularly easy to produce if the moving body includes a flat surface, or a surface formed by the displacement of a generatrix parallel with itself, for example a cylindrical surface. It is then possible to directly stick fluorescent or back-reflecting bands, parallel to each other, taking care to make the separating spaces between these bands opaque.

Among the possible variant embodiments, in order to take account of the roll of the head, there is used a first pattern M1 such as described which is oriented along the reference axis DR and a second pattern M2 oriented orthogonally to the first pattern as shown in figure 6. This configuration can be unique or it can be of smaller size and repeated several times in the form of a checker-board on a plane support 1. The referencing process enables the definition of the orientation DR and of the perpendicular direction DR_0 of the pattern M2. From this the computer can derive the roll about the direction DR. The simultaneous measurement of elevation/azimuth by DR and of head roll by DR_0 makes it essential that these two patterns remain within the field of the camera, or of each of the cameras. With this requirement, the field CH covered by the camera must be larger than if the roll is not taken into account. The orientation of the two orthogonal patterns on the helmet can be

any orientation whatsoever. By construction, the aiming direction in the axes XC YC ZC associated with the moving body 2 is known and it is known that this direction corresponds with that of one of the patterns and is orthogonal to the direction of the second pattern.

The second version mentioned with one camera is more economic; it will, however, be noted that the first described solution with two cameras is more accurate and that it can also be used according to the second process (figure 4) for each of the cameras; this allows redundancy in the computation and an even more accurate and more reliable measurement.

CLAIMS

1. A system for the spatial referencing of a direction associated with a moving body with respect to a structure, using means of emission carried by the body and means of opto-electric detection carried by the structure in order to define, by analysis of the detected signals and a computation, secant planes and by the straight lines of intersection of these planes, the direction to be referenced, wherein the detector means are constituted by at least one solid matrix sensor made from a charge transfer device associated with focusing optics, the means of emission being formed by an array of parallel emitting bands separated by opaque intervals and arranged on the body parallel to the direction to be referenced, in such a way that the image of the bands on the detector means is analyzed in order to define at least two secant planes, each with any image whatsoever and the centre of the corresponding associated optics, and their straight line of intersection which is parallel to the direction to be referenced.

2. A system according to Claim 1, wherein the bands are made from fluorescent material.

3. A system according to Claim 1, wherein the bands are made from back-reflecting material and in that the means of emission also include an emitting source which emits in the direction of the bands.

4. A system according to either of Claims 2 and 3, wherein the bands are stuck on a support whose surface is constituted by the displacement of a generatrix, the bands being parallel with this direction.

5. A system according to Claim 4, wherein the opaque intervals are produced with matt black paint.

6. A system according to any of Claims 1 to 5, including two matrix sensors constituted by CTD matrix cameras.

7. A system according to Claim 6 when appended to Claim 3, wherein the cameras are fitted with means of optical filtering in a wavelength band corresponding with the radiation emitted by the emitting source.

8. A system according to Claim 7, wherein the radiation is located in the infra-red range.

9. A system according to any of the previous Claims, used for a helmet aiming sight on board an aircraft, wherein the detector means are mounted on the aircraft structure and the bands are placed on the pilot's helmet.

10. A system according to any of Claims 1 to 8, wherein the bands are placed directly on the moving body insofar as this moving body has a flat surface or a surface resulting from the displacement of a generatrix parallel with itself.

11. A system for the spatial referencing of a direction associated with a moving body with respect to a structure substantially as described hereinbefore with reference to the accompanying drawings and as shown in Figures 1 to 3 and 5 of those drawings or modified substantially as described with reference to and as shown in Figure 4 and/or Figure 6 of those drawings.

Amendments to the claims have been filed as follows

CLAIMS

1. A system for the spatial referencing of a direction associated with a moving body with respect to a structure, using means of emission carried by the body, means of opto-electric detection carried by the structure ——————— and means of computation to define, by analysis of the detected signals and a computation, two secant planes and, by the straight line of intersection of these two planes, the direction to be referenced, wherein the detector means are constituted by n, where n is at least equal to one, solid matrix sensors made from a charge transfer device associated with focusing optics, and the means of emission are formed by an array of parallel emitting bands separated by opaque intervals and arranged on the body parallel to the direction to be referenced, such that images of the bands on the n sensors maybe analyzed by the computation means to define at least two secant planes, each defined by an image of one of the bands and the centre of the corresponding associated optics, and the straight line of intersection of these two planes, which is parallel to the direction to be referenced.

2. A system according to Claim 1, wherein the bands are made from fluorescent material.

3. A system according to Claim 1, wherein the bands are made from back-reflecting material and in that the means of emission also include an emitting source which emits in the direction of the bands.

4. A system according to either of Claims 2 and 3, wherein ——— the bands are stuck on a support whose surface is constituted by the displacement of a generatrix, the bands being parallel with this direction.

5. A system according to Claim 4, wherein the opaque intervals are produced with matt black paint.

6. A system according to any of Claims 1 to 5, wherein n is equal to two and wherein the two matrix sensors are constituted by CTD matrix cameras.

7. A system according to Claim 6 when appended to Claim 3, wherein the cameras are fitted with means of optical filtering in a wavelength band corresponding with the radiation emitted by the emitting source.

8. A system according to Claim 7, wherein the radiation is located in the infra-red range.

9. A system according to any of the previous Claims, used for a helmet aiming sight on board an aircraft, wherein the detector means are mounted on the aircraft structure and the bands are placed on the pilot's helmet.

10. A system according to any of Claims 1 to 8, wherein the bands are placed directly on the moving body insofar as this moving body has a flat surface or a surface resulting from the displacement of a generatrix parallel with itself.

11. A system for the spatial referencing of a direction associated with a moving body with respect to a structure substantially as described hereinbefore with reference to the accompanying drawings and as shown in Figures 1 to 3 and 5 of those drawings or modified substantially as described with reference to and as shown in Figure 4 and/or Figure 6 of those drawings.

PATENTS ACT 1977
EXAMINER'S REPORT TO THE COMPTROLLER
UNDER SECTION 17(5)
(The Search Report)

13

Application No.

8713983

FIELD OF SEARCH: The search has been conducted through the relevant published UK patent specifications and applications, and applications published under the European Patent Convention and the Patent Co-operation Treaty (and such other documents as may be mentioned below) in the following subject-matter areas:-

UK Classification F3C (CGB, CGD, CGX); G1A (AEE); H4D (DL)

(Collections other than UK, EP & PCT:) Selected US specifications from IPC sub-classes F41G, G01B, G01S

DOCUMENTS IDENTIFIED BY THE EXAMINER (NB In accordance with Section 17(5), the list of documents below may include only those considered by the examiner to be the most relevant of those lying within the field (and extent) of search)

Category	Identity of document and relevant passages	Relevant to claim(s)
	None	

CATEGORY OF CITED DOCUMENTS

X relevant if taken alone
Y relevant if combined with another cited document
P document published on or after the declared priority date but before the filing date of the present application
E patent document published on or after, but with priority date earlier than, the filing date of the present application

Search examiner K E Williams

Date of search 28 January 1988

SF :